SPALLATION NEUTRON SOURCE
QUALITY GUIDE

Guide for Electronics Design

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Guide for Electronics Design

1 Introduction

There is great variety in electronics design projects. However, there are several distinct phases to successful development, here we have identified four phases from concept to readiness for manufacture, each with its own level of peer review, and evaluation required to move on to the next phase. By following these very basic guidelines, the design team will discover and avoid many unnecessary pitfalls which can cause additional cost, delays and even design failure. Each of the identified phases have their own requirements and discussions necessary to evaluate the project's movement from one phase to another. As required in the procedure, during each phase the project will be evaluated on the data provided, any findings, and whether or not it is still within the projects goals to continue to the next phase which will ultimately lead to successful deployment. At any time, the design management can decide to revert back to a previous phase, repeat the current phase, or cancel the project entirely.

2 Purpose and Scope

This guide is a supplement to the SNS Equipment Design Procedure, for new electronics project development. The development is seen as five distinct phases, with standards for determining completion or cancellation after each phase.

2.1 Applicability

This guideline is intended to be used on any electronics project for a development which meets or exceeds the following criteria:

- Costs exceeds $10K for production of final design
- Development of concept takes > 1 Man Month effort.
- (note that additional mandatory criteria are covered in the QA grading step, 6.1 a) of the design procedure)

A new project is started when one of the above criteria is met, and a new idea, or task has been presented to the design team, or when an existing project has been through 5 minor revisions or has had 10 Engineering Change Orders or ECO's applied to it. At this point a product should be submitted for design review by the DRC to determine the design's obsolescence, upgrade path or replacement. The design team can then start the process for a major revision or an entirely new project.

3 Electronics Design Process

This section explains each design phase with a basic guideline for determining success or failure of the phase. An individual phase can take minutes or weeks. No phase should be skipped, although how much effort is involved in each phase is unique to the task.

3.1 Phase 1 - Conceptual Design

There may be a specific need such as a deficit in system performance,a requirement, or an opportunity based on an innovative idea by one of the technical staff. Typically a supervisor, or senior design team member or members determines the need to make the idea a project and move on to phase 2. The outcome is a documented concept, preliminary specification, and project goals.

a) A simple written outline is required, identifying the particular design idea. The originator discusses the outline with their immediate supervisor.
b) The supervisor decides to proceed or hold the project for later. If the decision is to proceed, the design group leader meets with the quality assurance representative to establish the QA level as the conceptual design begins. Peer review requirements are informal for level 3 design and DRC reviews are optional for level 2.
c) Notification of the start of a project should be sent to all personnel involved or desired for the design team. A Project file is started in Projectwise with the conceptual outline and the QA grading record.
d) The design team lists the benefits and risks, holding discussions and doing whatever research is needed to compile the list. Risks, like benefits, may be in dimensions of cost, performance, reliability, repairability, ALARA, ease of use, schedule, difficulty, etc. The SNS Guide to Analyzing Risk may be used to help organize the information.

e) Design requirements - List the fundamental requirements of functional or operational performance and interfaces which must be achieved in total for the design to be useful.
f) Interface requirements - Identify all interface points with other items and define all requirements necessary to permit successful interaction. Specific individuals responsible for these interfaces should be clearly identified.
g) Any meetings necessary for determining movement to the next phase are scheduled here. For level 3 designs, a simple design review by the concept originator, the immediate supervisor, and any design resource personnel deemed necessary by them is enough to start the next phase. Formal CDR review by the DRC is required for QA level 1 or optional for level 2 designs.

Note: QA level 3 design concept files may be held indefinitely until such time that resources become available, or the idea becomes a possible solution to an immediate problem.

3.2 Phases 2 and 3 - Preliminary Design

Following the CDR (or informal conceptual review for QA level 3 designs), the preliminary design effort is divided into two phases. For level 3 projects, a formal plan is not required and feasibility checking can begin immediately. For projects reviewed formally, the CDR report is entered into the SNS Action Tracking database as a review, and the resulting actions are listed as actions with persons assigned and due dates. The plan for preliminary design is listed as a set of actions in the tracking system also. The actions include determining feasibility.

The group leader will arrange for independent verifications as required, assuring independence from those working on the original design even if it requires outside resources.

Phase 2 - Feasibility

Determining feasibility can be a short phase of a project. The desire here is to have the design team discuss the feasibility of the project concept, and identify one or more possible solutions, or experiments to determine the viability of the concept. The purpose of this phase is to determine the method by which the design team will verify the concept's ability to achieve the desired results. During this phase, possible solutions and/or methods are discussed.

a) A brief discussion via a formal or informal meeting, (email, or open discussion) is made to determine whether the idea has merit and can be achieved using resources, and technology available. The outcome of this meeting should be one of the following.
b) A decision to either hold the concept until resources become available
c) A list of calculational, simulation, and experimental methods for determining project viability to be used in the next phase.
d) Concept determined unfeasible and project cancelled
e) Documents supporting feasibility should be prepared before the review of this phase, including:
    - reports of similar designs published or commercially available,
    - application or tech notes from parts vendors,
    - component datasheets,
    - experiments to be performed for testing feasibility,
    - experimental results anticipated,
    - and any calculation, simulation or modeling data required of the entire experiment or parts of the experiment.
f) A feasibility report by the design team is then compiled. This report should include the recommendation of the team made regarding feasibility, what experiments or studies are to be done and what resources or additional work is necessary before proceeding to the next phase. Specific goals should be written out outlining what methods, proofs or outcomes are to be used to verify feasibility. The feasibility report is part of the design documentation to be presented at the PDR.
g) Specifications for the design product should be formalized.

Note: QA level 3 projects can be held in the feasibility phase indefinitely until such time that resources become available, or the group leader determines it is time to move forward.

Phase 3 - Experimentation

During this phase, any new methods or possible solutions will be tested for practicality and to determine which method is the best fit for the final design development. Documents to be generated during this phase include experimental results and comparisons to calculations, simulations, and modeling.

a) Any proof-of-concept experiment determined in the previous phase, and even new ones developed during any ongoing experiment, should be planned and the experiments performed by the design team, and results should be documented. Any applicable modeling should be performed as per the document prepared in the feasibility phase.
b) Reports of the experimental results should be compiled and issued.
c) Any experimental results should be checked against the design goals and any applicable simulation data or modeling done during this phase.
d) Any change in specifications called for by the results of the experimentation may require the revision of documents prepared in the feasibility phase.
e) The specifications to be met by the final design are issued as part of the documentation for the PDR.

The team should submit for the PDR (or informal review if QA level 3) the design product specifications and goals as well as pass/fail parameters for a prototype to be constructed as proof of the design. It is important that once a specification is developed that it is used as the guide for goals and results.

Once a specification is accepted by all interested parties, it becomes the standard by which design criteria and results will be judged. Any modifications outside this specification require revision.

A report is necessary, covering the experiments performed and methods used, detailed results and conclusions of the design team, and a summary for the PDR or informal design review meeting.

3.3 Phase 4 - Final Design

Following the PDR (or informal preliminary review for level 3 design), the final design effort begins. For projects reviewed formally, the PDR report is entered into the SNS Action Tracking database as a review, and the resulting actions are listed as actions with persons assigned and due dates. The plan for final design is listed as a set of actions in the tracking system also.

The overall plan for final design includes:

- The group leader will arrange for independent verifications as required, assuring independence from those working on the original design even if it requires outside resources.
- The final design phase requires appropriate planning, scheduling, and budgeting, which should be approved as a minimum by the group leader.
- The technical lead develops the technical plan which identifies the tasks, key components, and method of accomplishment for the detailed design.
- The plan is reviewed and approved by the group leader and the DRC (not required for QA level 3).

Prototype Development

Most electronic designs include a prototype step. There are several basic steps necessary to ensure successful prototyping. The specification is the criteria document used to judge prototype success.

To being construction and verification testing of the prototype, documentation must be prepared to guide the work, including schematics, printed-circuit board layout, production support documents, tech notes relating to performance, and a user guide with maintenance information. All of these documents can be at a preliminary level as prototype construction begins, since they will be subject to revision at the end of this step.

As the design progresses, internal verifications should progress also, to minimize the loss when changes must be made to meet requirements. External verifications may also begin as work progresses.

Prototype Development guidelines.

a) Assemble the design team from resources determined from the previous phase, and discuss the goals outlined by the project need, and experimental results. This is the first required formal design team meeting.
b) A list of additional resources and or materials is generated for review by the project supervisor to allocate resources.
c) Based on this written specification and resource allocation, the design team starts the electronic schematics, mechanical layout, and any software or firmware development.
d) A project prototype is developed; there should be more than 2 prototypes, typically 5-10 so that any infant mortality or production issues can be vetted out.
e) Prototypes should be thoroughly tested, for accuracy, reliability, power consumption, environmental sensitivity, (noise, temperature, humidity, radiation). According to the specification generated in the last phase.
f) After reasonable testing of the project prototype, the results should be evaluated. The evaluation should answer these questions:
    - Did the prototype meet all desired specifications? If not, what steps can be taken to improve or correct any differences?
    - Are there any modifications which make the product more useful to the end user, easier to manufacture or maintain, or cost savings?
    - Can the design be made more reliable and less sensitive to the operational environment?

The documentation package should include the following documents, as applicable:

- **Electronics:** Schematics, component data sheets, Bill of Materials, PCB layout / gerber files, wiring diagrams for chassis or enclosures
- **Mechanical:** Any data sheets for materials and suppliers, CAD prints of hardware or enclosures
- **Software:** Complete libraries, code and development notes and support documents. Versions of compilers or synthesizers and tools used at the time of this build. Any applicable tech notes relating to software or firmware development. A list of tools for in circuit testing or programming.
- **Support Documents:** A user guide or manual, maintenance manual, applicable tech notes for use and trouble shooting, and testing results.

After the final design is complete with all documentation, any required independent verification is done and reported.

Final Design Review

The QA level 3 project can be reviewed by the design team and group leader. QA level 1 designs (and optionally for level 2) require a formal FDR to validate the final design before it is released for procurement of production parts or otherwise used as intended.

The technical lead presents the design at the FDR, and corrects the design as required following the review.

3.4 Phase 5 - Preparation for Production

Following the FDR (or informal final design review for level 3 design), the design can be finalized. For projects reviewed formally, the FDR report is entered into the SNS Action Tracking database as a review, and the resulting actions are listed as actions with persons assigned and due dates.

Production Guidelines

a) Any recommendations or design changes from the previous design review are implemented and the design documents are altered to reflect these changes.
b) Resources are allocated to order materials and assemble the required number of production units.
c) A test plan and/or procedure is developed, written up and reviewed by the design team.

d) Complete design documentation package is required to include any of the following as applicable to the design;

- Overview document including, original concept, goals and specifications
- Complete electrical, and electronic schematics
- Mechanical prints
- Software / firmware outline and design guide, API.
- Test and maintenance plan
- Datasheets from any OEM parts
- Complete bill of materials
- Assembly drawings and instructions.
- Troubleshooting guide.
- Copies of any purchase orders or quotes so new parts and vendors can be identified.